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A UHF RFID sensor tag system with externally connected sensor component

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Summary:
The presented work focuses on the development of RFID sensor tags utilizing external sensor devices via long cable connections of up to 4 m, which is often needed to overcome spatial restrictions in different machines of industrial processes, due to fully metallic housings or limited space conditions. The influences of the large distances between sensor element and RFID integrated circuit on the tag of the RFID sensor system itself are analyzed and practical issues are addressed to enable a measurement over a long read-out range with a standard UHF reader device.

Keywords: RFID sensor system, UHF reader, wireless measurement, sensor tag, RFID technology

Introduction

Radio frequency identification (RFID) sensor technology is an upcoming technology that is more and more applied in many applications and already implemented in the industrial field, where process control, health state monitoring and condition recognition are of main interest. There are several companies on the market, like IDENTIV, microsensys, XERAFY and HID that develop RFID sensor tags. Mainly, the chip sets of the company ASYGN or AXZON are employed in existing solutions. While ASYGN offers an integrated circuit (IC) with a fully integrated sensor front-end circuit, to connect either external sensor devices to the chip or utilize internal sensors, the company AXZON targets solutions with a different approach. They realize the discretization of the measured quantity by directly influencing the antenna structure and analyzing the relative strength signal indicator (RSSI) value, which can be read-out by their integrated engine, called CHAMELEON. Therefore, the antenna structure itself acts as sensing device, which leads on one hand to a cost reduction, but on the other hand offers limited sensing capabilities with only a few discrete values. An intense market review revealed that the commercially available RFID sensor tag solutions, use different types of chips of the previously mentioned chip manufacturers, exploiting only their internally integrated sensor devices.

In the literature several solutions for sensor attached RFID systems [1], including optimized antenna structures for long read-out ranges [2] are reported, which are even applied in industrial applications [3], but always without long sensor wires.

Development of the RFID Sensor Tag

In the presented sensor tag the ASYGN chip AS3212, which includes a fully integrated sensor front-end circuit to attach a Wheatstone bridge configuration is used. To measure the temperature at hard-to-reach places, where it is not possible to install a tag antenna structure or transmitter antenna due to a metallic environment, long connection wires between the sensor tag and the sensing element are required. In this case several issues arise. First, the overall input resistance of the connected bridge circuit should be matched to about 1 kΩ. Secondly, the low bridge supply voltage of 1 V must be considered. Finally, it must be ensured that the measured value can be correlated to the real physical quantity, for example temperature.

Beside these boundary conditions, a long cable within the configuration introduces a non-negligible inductivity with an effective area that might induce high voltage peaks, if being exposed to an electromagnetically disturbed environment. Additionally, a copper wire itself is sensitive to any pressure. To overcome this, a common technique is to twist the supply and return conductor to the sensor component, avoiding a wire loop and hence the induction of any unwanted signal.

Long connection wires also add a not neglectable resistance value, that falsify the measured temperature with the PT1000. This is particularly relevant, if the wires are very thin, like 100 µm in diameter and 4 m long. Thereby,

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due to the twisting of the wires, an additional length extension of up to 5% can be expected. This value leads to an absolute error that must be compensated. Figure 1 shows a commonly used arrangement that does not offer this possibility.

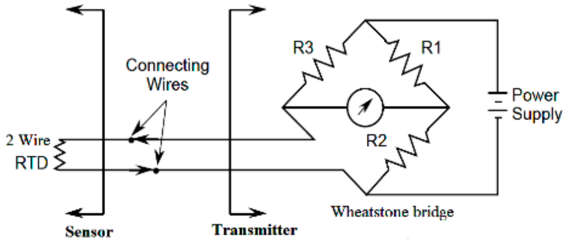

Fig. 1. Common setup of a Wheatstone bridge for temperature measurements.

To compensate the effect of the long connecting wires, an additional wire with a short circuit is connected between R3 and its power supply feeding pin depicted in Figure 2.

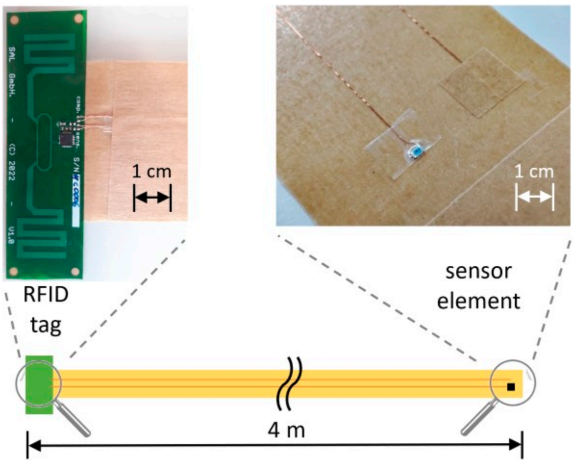

Fig. 2. Developed sensor system with RFID chip, antenna and connected sensor with parallel compensation wire to equalize the resistance value.

Measurement Results

As the AS3212 is a UHF-based RFID chip, the IC with the attached sensor implemented in the Wheatston bridge is connected to an antenna structure. To minimize the component count, also the matching circuit is realized as a lumped element structure.

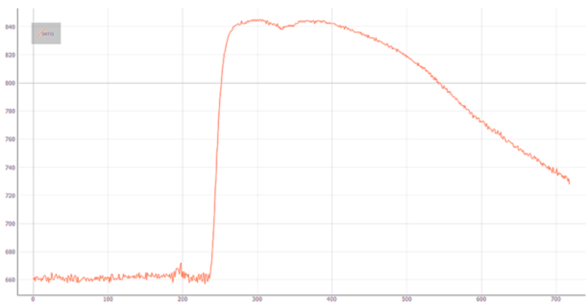

Fig. 3. Temperature measurement with 4 m long sensor wires. Binary values just represent the voltage difference within the bridge configuration.

As the sensor circuitry represents an additional load to the chip, also the matching circuitry is affected. A detuning increases the power consumption by additionally reducing the read-out range. Therefore, this load scenario must be considered. Figure 3 depicts a typical temperature measurement result, achieved by heating up the sensor with a hot air gun up to +100°C.
The read-out over a range of up to 2 m is performed with a Impinj Speedway R420 reader unit, connected to a 11 dBi antenna of Kathrein.

Conclusion and Outlook

The presented work describes the setup of a UHF RFID sensor tag, that is capable to be connected to external sensor elements with long wires and therefore enables the possibility to read out temperature values wirelessly, even if the measurement point of interest is hardly accessible. Although the wiring introduces a high resistive load to the RFID chip, by optimizing the matching circuitry wireless read-out ranges of up to 2 m could be achieved.
These promising results, show the great potential of such a UHF RFID sensor system to be used in many types of industrial applications, where no appropriate solution exist. Nevertheless, further improvements and optimizations regarding the matching must be performed to enhance the read-out range and additionally investigations in the system performance for different sensor wire lengths might be useful, to be able to offer solutions for any kind of problems in the industrial environment in the future.

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